



# Energy Infrastructure:

## The World's Arterial And Circulatory System

Sixth Annual Rice Global Forum  
Rice University  
September 8, 2003  
Houston, Texas

Presented By  
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# Energy Is The Earth's Most Precious Resource

- Modern energy was the greatest 20th century innovation.

- Electricity
- Internal combustion engine
- Potable water
- Age of technological revolution
- Modern food system
  - Hybrids
  - Fertilizer
  - Refrigeration
- Health system

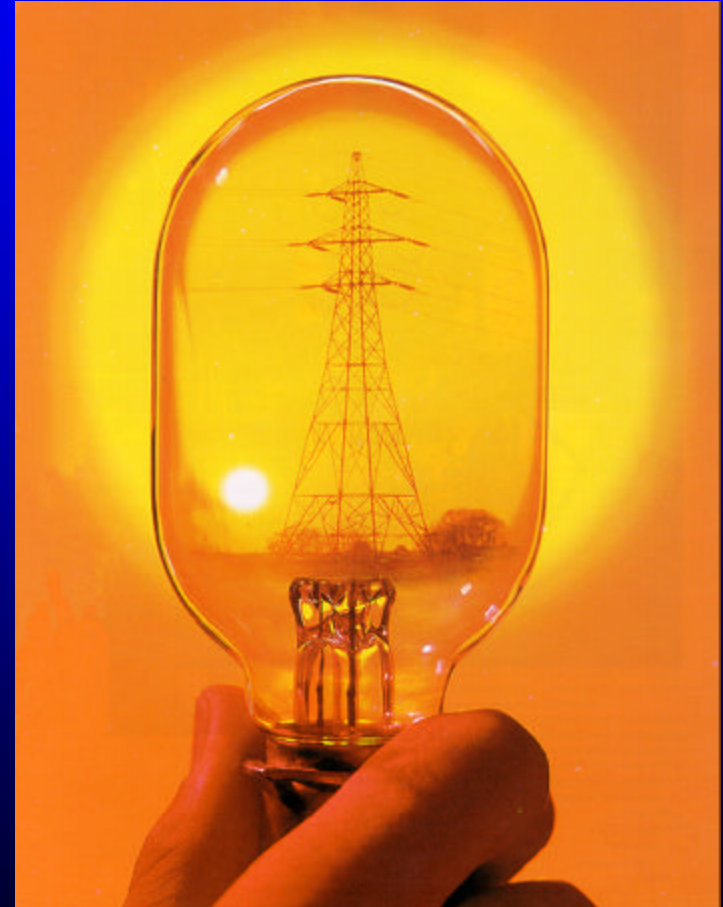


Without primary energy,  
none would happen

- Modern energy made wood, waste and dung obsolete in many parts of the globe.
- This miracle invented “prosperity.”

# Useable Modern Energy Requires Complex “Infrastructure”

- No element of energy simply “turns on.”
- Each component has its own unique set of critical transformations and transmission from “raw energy” to useable energy.
- Many parts of this infrastructure are extremely energy intensive.
- Final “Point of Consumption Yield” varies enormously. (It takes energy to create useable energy.)
- Each energy component has its own unique peak capacity.
- All have finite physical lives.



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# Much Of Our Energy System Was Built Between 1947 And 1975

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- Global energy demand exploded post-World War II.
- By mid-1970s, last major transformation/transportation systems were built.
- Bulk of primary energy systems today were constructed in the 1950s and 1960s.
  - Last giant oilfields were discovered by 1975.
  - Most of OECD power plants were built prior to 1975.
  - Major oil and gas pipelines were built pre-1970.
  - Only a handful of refineries were built post-1970.

# Over Last Decade, Spare Energy Capacity Disappeared

- Reserve margins in power grids eroded to skinny levels.
- Petroleum stocks fell in days' use by 25% to 30%.
- Refinery utilization in most of the world rose from 70%-75% to 90%-95%.
- Oil and gas pipelines operate at 99% to 100% capacity at all times.
- Global tanker fleet is always over 95% full.
- “Shut-in” daily oil and gas supply is >2% of daily use (or less!).

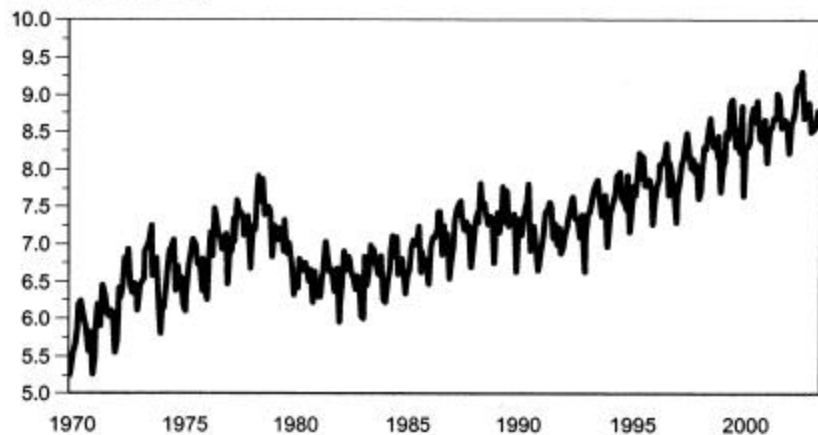


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# U.S. Motor Gasoline: We Squander Our Transportation Cushion

**Figure 12**  
**US Monthly Gasoline Consumption**

Million Barrels per Day

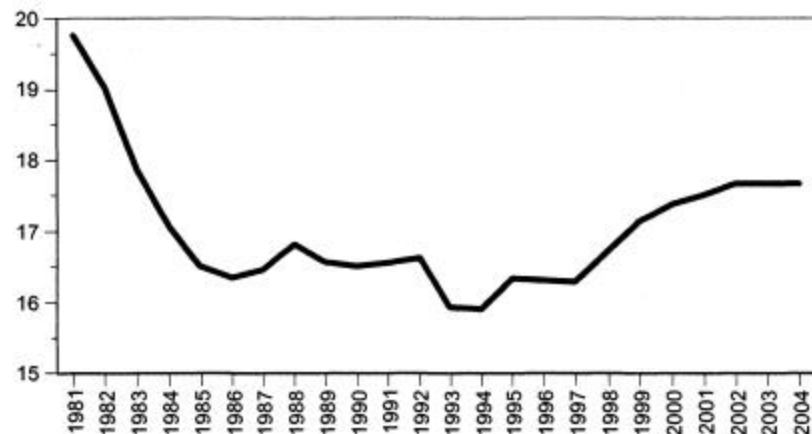


Source: US DOE.

R/V

**Figure 13**  
**Atmospheric Distillation Capacity of US Refineries**

Million Barrels per Day

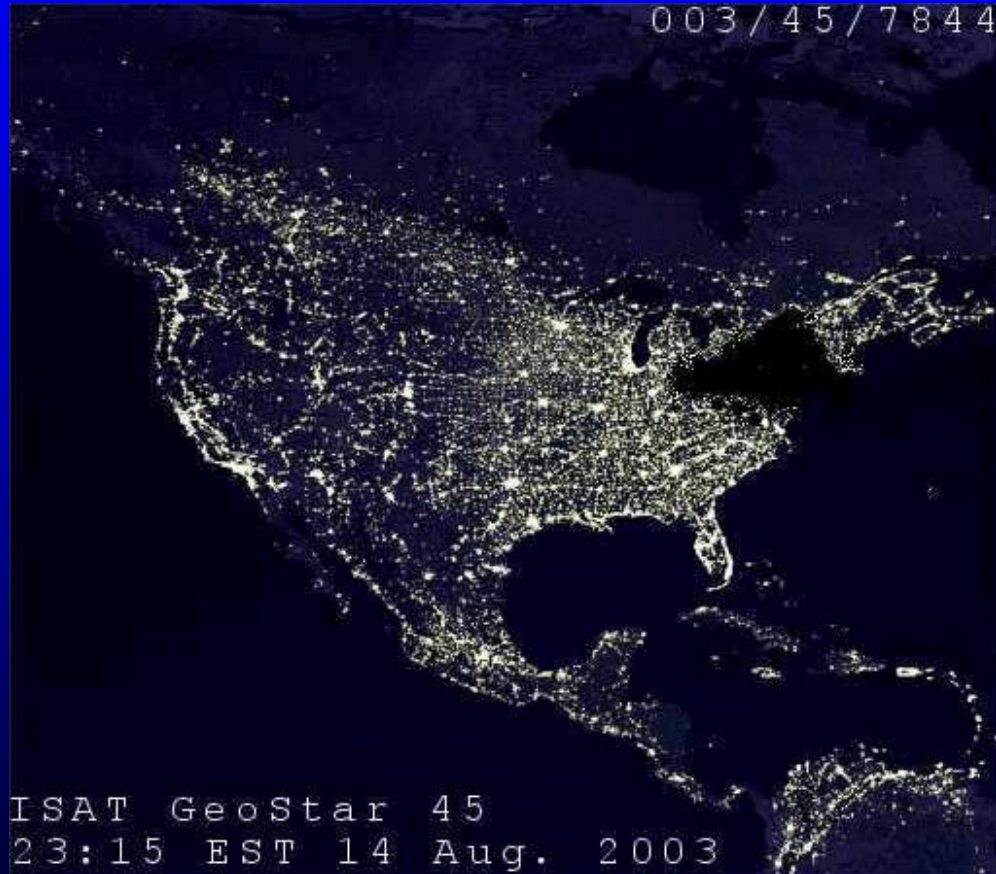


Source: US DOE.

R/V



# August 14, 2003 Blackout Highlighted The Fragility Of U.S. Power Grid



- After 1965 blackout, the U.S. expanded its power generation base by 10% ever 5 years.
- In 1990s, we added 4% in first 5 years, 2% in the last 5 years.
- Summer of 1999: 25 - 30 discrete "power events."
- 2001: California economy's melts down.
- 2000 - 2003: U.S. added 220 MW of new generating capacity (all gas-fired - a mistake).
- But little expansion happened in transmission of electricity.

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# The North American Grid Is Old



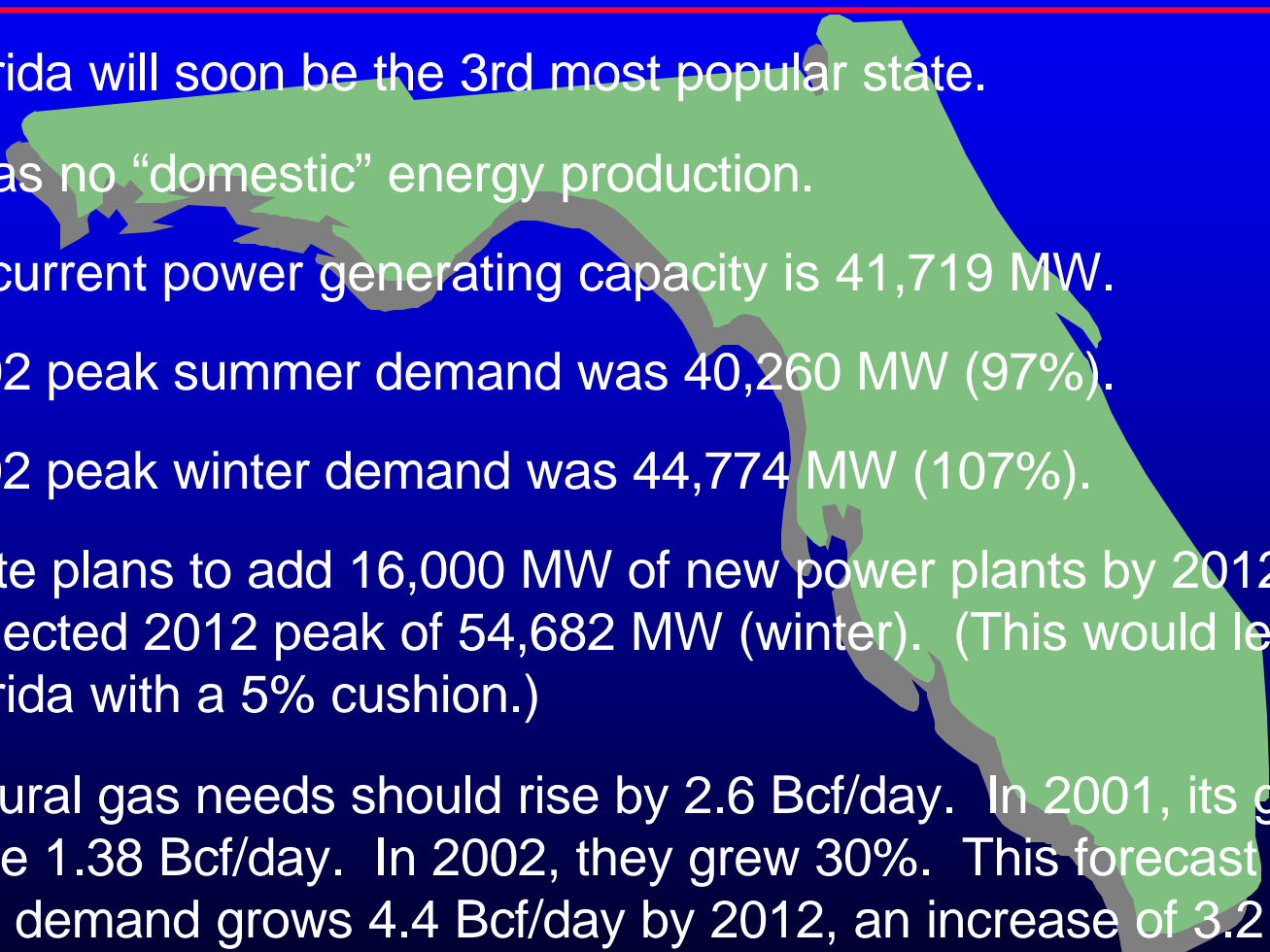
*Image courtesy of World Energy.*

- U.S. transmission grid is extremely complex.
- 150,000 miles of lines crossing multiple boundaries: utilities, states, Canada and Mexico.
- 1988 to 1997:
  - Transmission investment fell by 0.8% per annum.
  - Maintenance investment fell by 3.3% per annum.
  - Power demand grew by 2.4% per annum.
- 1998 Onward: Internet spun demand to far higher levels.

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# Florida Is A Classic Case Study Of What Went Wrong

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- Florida will soon be the 3rd most popular state.
  - It has no “domestic” energy production.
  - Its current power generating capacity is 41,719 MW.
  - 2002 peak summer demand was 40,260 MW (97%).
  - 2002 peak winter demand was 44,774 MW (107%).
  - State plans to add 16,000 MW of new power plants by 2012 to meet projected 2012 peak of 54,682 MW (winter). (This would leave Florida with a 5% cushion.)
  - Natural gas needs should rise by 2.6 Bcf/day. In 2001, its gas need were 1.38 Bcf/day. In 2002, they grew 30%. This forecast assumes gas demand grows 4.4 Bcf/day by 2012, an increase of 3.2 times 2001 levels.

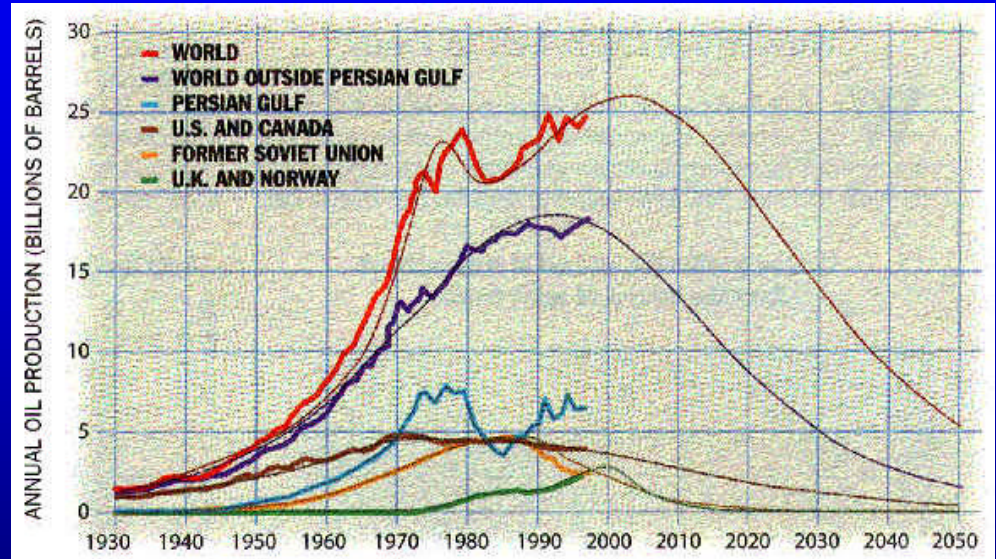
# Power Generation Surge Created Growth For Natural Gas

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- Adding 220 MW of new gas-fired power plants created a bonanza for North American natural gas.
- But natural gas supply peaked and is now in decline.
- 1992 to 2001 “flat supply” was boosted by rapid growth in non-conventional supplies.
- Industrial use of gas is now endangered.
- As is the use of U.S. new power plants.

# Our Spare Energy Capacity Is Gone

- There is no serious cushion of useable energy capacity left anywhere on the globe.
- Far worse, major parts of the existing infrastructure is old, badly deteriorated or even obsolete.
- World energy demand cannot grow without infrastructure expansion.
- World energy demand cannot even remain stationary without remodeling and rebuilding existing base.



# Why Our Energy Cushion Evaporated

- NO ONE consciously decided to use up global “safety valve.”
- Energy demand grew when many assumed it would not.
- Energy prices either stayed flat or declined.
  - This further stimulated demand.
  - And made new energy investments “bad deals.”
- Energy “deregulation” sped up this process.
  - Free markets never intentionally build redundant capacity.
  - Free markets punish spare capacity as “glut.”
- As demand periodically exceeded supply, consuming spare capacity became out “energy bridge.”



# Technology Sped The Process Of Eroding Cushion

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- The internet created a surge in power use.
- Globalization increased developing country energy use.
- Oil and gas technology created new era of oil and gas.
  - Small fields became commercially viable.
  - Horizontal drilling/multizone completions created monstrous rates of production decline.
- Many energy observers assumed “New Economy” used less energy and made supplies easier to find.

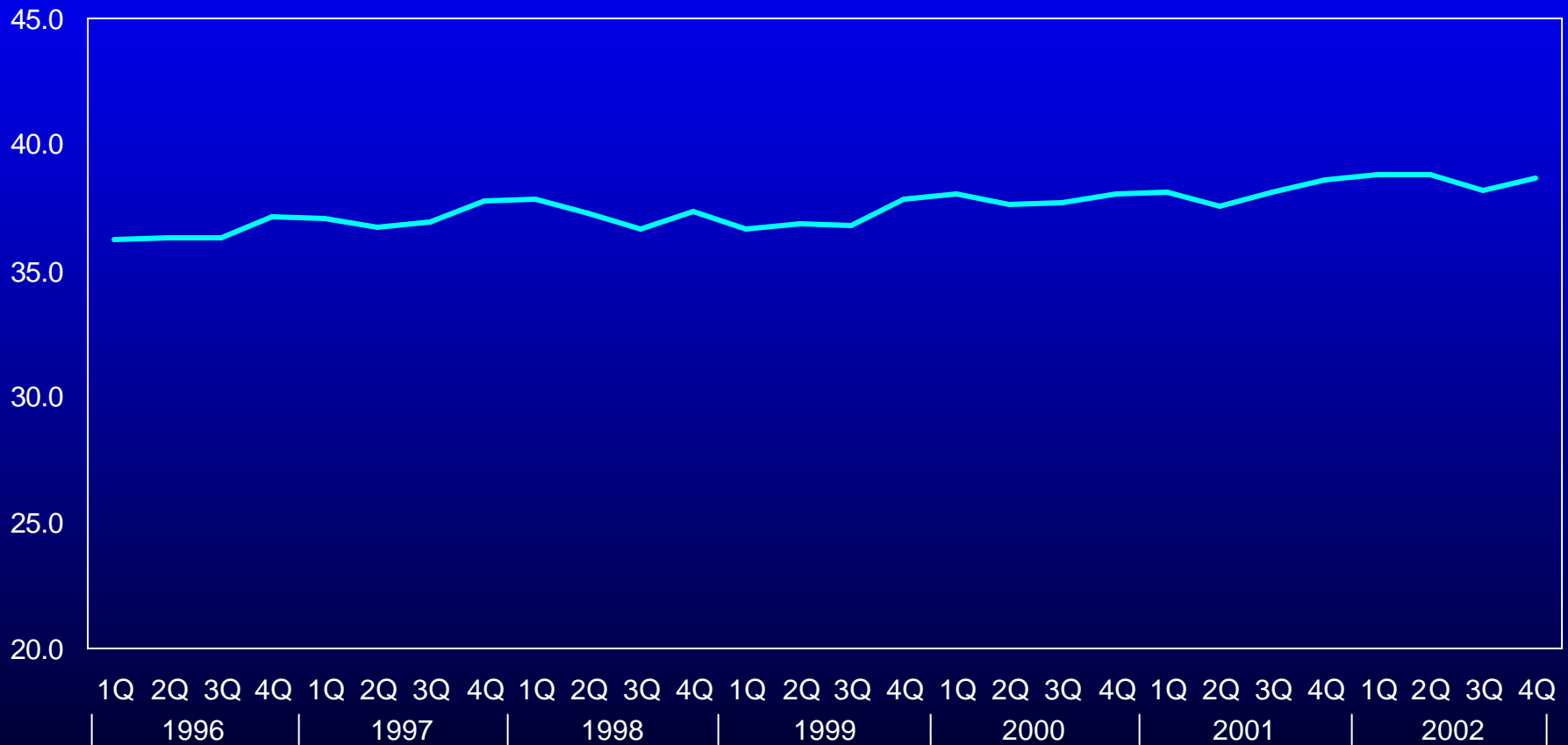
# Oil Supply Did Not Behave As Planned

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- Non-OPEC, non-FSU supply has been flat for 7 years.
- FSU gains are cloaked in mystery - some real, some imaginary. None have the absolute ability to sustain growth.
- Top E&P companies spent \$195 billion per barrel produced (BOE) to barely grow.
- The Middle East oil supply has likely peaked.



# Non-OPEC (*Excluding FSU*) Supply Never Surged



# U.K. North Sea Is Classic Depletion Case Study

## Top 9 U.K. Oilfields

	Peak <u>Production</u>	December <u>1994</u>	<u>2002</u>
Forties	500	131	54
Brent	410	121	40
Beryl	120	108	32
Magnus	129	159	39
Brae East	115	101	8
Miller	135	133	20
Piper	110	94	16
Scott	105	169	39
Nelson	<u>160</u>	<u>173</u>	<u>80</u>
Total	<u>1,784</u>	<u>1,280</u>	<u>328</u>
Percent Of U.K. Production		49%	15%

16% Per Annum Rate Of Decline (Net)

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# Top 10 E&P Companies Spending 2000 To 2002

## 2000 Costs Incurred (Millions)

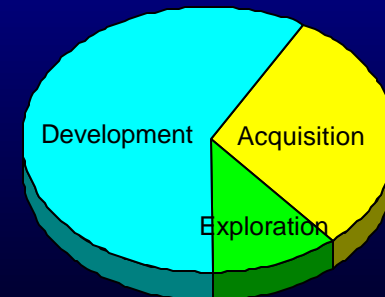
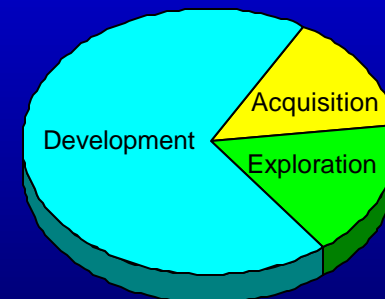
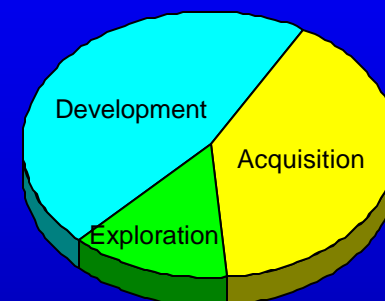
Acquisition	\$25,549
Exploration	8,617
Development	<u>29,316</u>
Total	<u>\$63,483</u>
BOE Bbl Produced (BOE/d, 000)	22,487

## 2001 Costs Incurred (Millions)

Acquisition	\$ 8,154
Exploration	9,218
Development	<u>37,974</u>
Total	<u>\$55,347</u>
BOE Bbl Produced (BOE/d, 000)	23,107

## 2002 Costs Incurred (Millions)

Acquisition	\$23,147
Exploration	8,430
Development	<u>44,617</u>
Total	<u>\$76,193</u>
BOE Bbl Produced (BOE/d, 000)	24,091



Source: Company annual reports and SEC filings.

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# Five Company Sample

- Production grew by 1.2% per annum.
- Total E&P spending was \$66.2 billion.
- Acquisitions only totaled \$2.3 billion.
- \$63 billion was needed to keep production “flat.”
- This represents \$1,800 a year per average barrel/day.

	Production (000 BOE/Day)			Spending (Dollar amounts in millions)		
	2000	2001	2002	2000	2001	2002
ChevronTexaco	2,741	2,695	2,626	\$ 6,042	\$ 6,696	\$ 5,814
ExxonMobil	4,277	4,255	4,238	4,277	4,255	4,238
PetroChina	2,327	2,349	2,385	4,664	4,782	5,587
Statoil	988	991	1,054	2,102	1,876	2,086
TOTAL	1,761	1,836	2,071	4,422	4,584	4,766
Total	<u>12,094</u>	<u>12,126</u>	<u>12,374</u>	<u>\$21,507</u>	<u>\$22,193</u>	<u>\$22,491</u>

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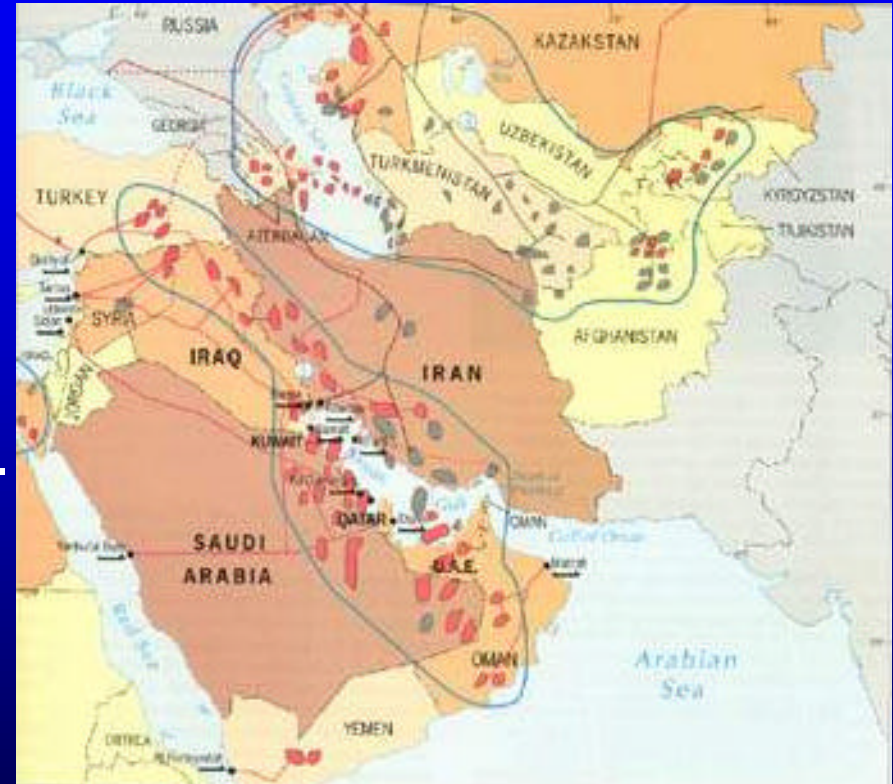
# Middle East Is Only Place Any Spare Capacity Might Exist

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- Future reserve estimates for oil and gas are remarkable.
- Conventional wisdom suggests Middle East energy is almost free.
- The only “nervousness is geopolitics of this complex region.

# The Real Story Of Middle East Energy

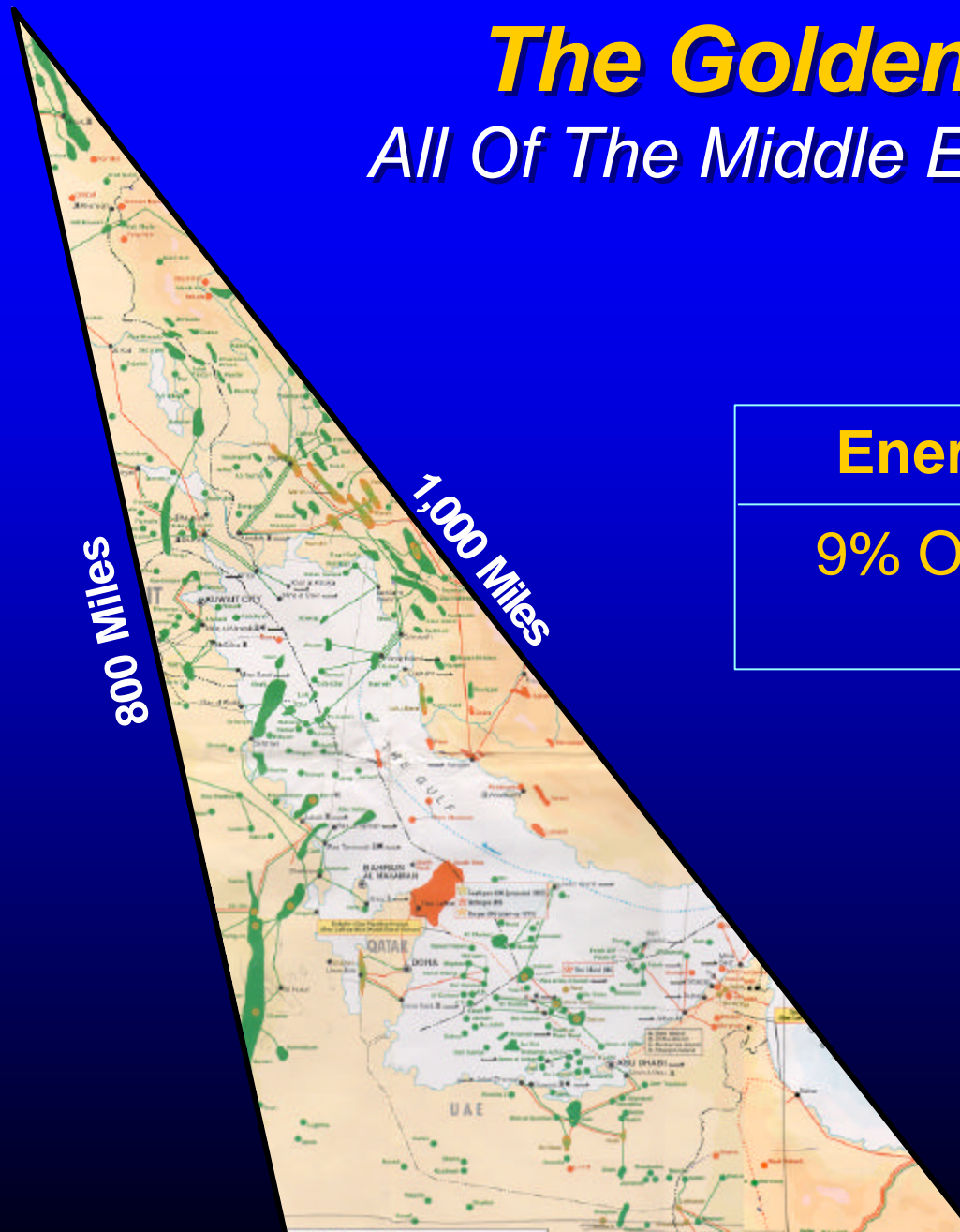
- Exploration success ended decades ago.
- All the giant oil and gas fields are tightly bunched into Golden Energy Triangle.
- Saudi Arabia is now acknowledged to be only producer with vast amounts of usable, already discovered reserves.
- Is the Saudi Arabia myth real?





# ***The Golden Triangle***

## *All Of The Middle East Oil And Gas*



**Energy Triangle**

9% Of Middle East  
Surface

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# Relative Size Of The Middle East Golden Triangle



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# Middle East Demographics

- 40 million new people in last 7 years.
- By 2015, the Middle East could have more people than currently in the U.S., in 55% of the land mass.

	Square Miles	Population (In Millions)	
		1993	2000
Syria	71,498	14,070	16,200
Jordan	35,135	3,632	4,900
Iran	632,457	60,500	63,700
Iraq	169,235	18,815	23,300
Saudi Arabia	830,000	15,985	20,700
Yemen	203,850	12,215	17,500
Oman	82,030	1,617	2,400
Kuwait	6,880	2,388	2,000
UAE	32,278	2,590	2,900
Total	<u>2,063,363</u>	<u>114,100</u>	<u>153,600</u>

Sources: World Bank (2000 Population); Rand McNally, 1993.

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# Saudi Arabia Is The Dominant Oil Producer In The Middle East

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- All other Middle East producers pale in comparison to Saudi Arabia's production, spare capacity and reserves.
- Saudi Arabia became most important oil exporter once U.S peaked.
- While often not trusted, Saudi Arabia has constantly tried to become world's most trusted supplier of oil. (It is all they have.)
- Saudi Arabia is assumed to hold virtually limitless amounts of cheap oil.

# Saudi Arabia's Oil And Gas Challenges

- No major exploration success since the 1960s.
- Almost all its production comes from very old fields.
- Almost every field has high and rising water cut.
- Ghawar, the world's largest field, injects 7 million b/d of seawater to prop up the reservoir pressure.
- Outside “North Ghawar,” permeability and porosity are hard to find.
- Some key fields never worked.
- Others are watering out.
- It takes “fuzzy logic” to plan for Saudi Arabia's future.



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# Pending Saudi Oil Challenges Paper Will Be Revealing

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- Last spring I decided to tackle an in-depth assessment of Saudi Arabia's oil and gas resources.
- Downloaded over 150 detailed technical papers written by Saudi technicians on the real problems facing each significant field.
- These findings fly in the face of everything I have heard over the past 3 decades about Saudi's abundance in oil resources.
- The research has totally changed my long-term thinking about our energy challenges.

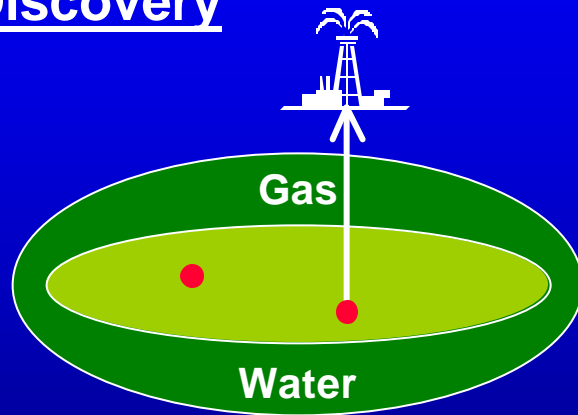


# What Saudi Arabia's Real Energy Costs Might Be

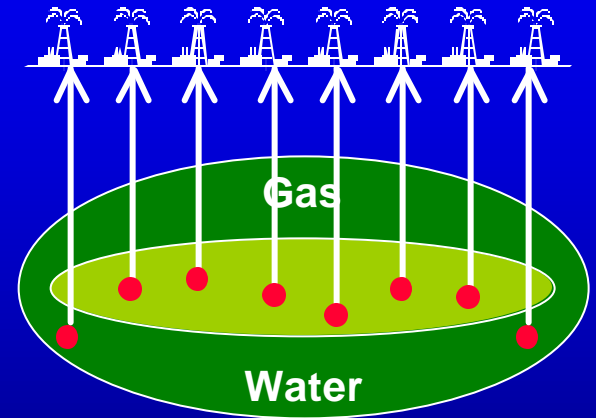
- Saudi Arabia is no longer a low cost producer.
- Lifting cost must be rising exponentially.
- Natural gas finding costs are extremely high.
- What is Saudi Arabia's "right price" for oil?  
Does anyone really know?

# Oil Fields Do Age

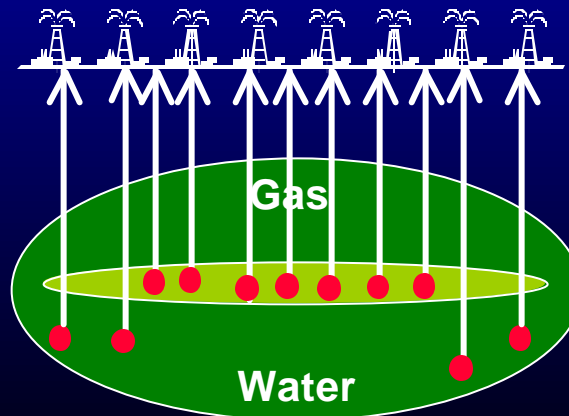
## Discovery



## Half-Life



## Old Age



# World Has Enjoyed Cheap Oil For Two Decades

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- Global economy has enjoyed stable and low oil prices for almost all of the past 2 decades.
- This price is no longer economically viable for either public companies or any OPEC producer.
- Natural gas prices in most areas need to also rise.
- Both resources might either be peaking or have already peaked.
- The issue of oil and gas “peaking” deserves a far more serious analysis.

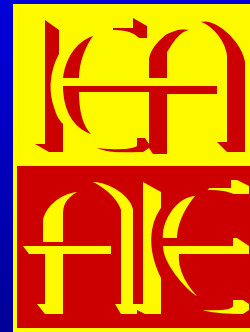
# The Global Economy Does Not Work Without Energy

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- Local economies can become less energy dependent by exporting energy intensive efforts.
- But exports have to find homes with ample energy.
- A major energy “myth” was that energy was becoming an even smaller percentage of GDP.
  - U.S. reduction came in brief era:
    - Nuclear energy appeared.
    - Oil stopped creating kilowatts.
    - “Rust Belt” economies shifted overseas.
- The global economy still barely uses energy.
- As it expands, energy use has to also grow.

# How Much Energy Does The World Need?

- IEA's long-term model assumes total energy use will almost double by 2030.
- Their model is "conservative."
  - 2030: 1.5 billion people will still have no electricity.
  - 2030: World population only grows to 8.5 - 9.0 billion.
  - 2030: Energy intensity constantly falls.
- Current demographics/energy facts do not support these assumptions.
- Only energy certainty: Energy demand will never exceed energy supply.



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# How Much Will Creating Energy Growth Cost?

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- IEA's World Energy Outlook 2003 will address this subject for the first time in history.
  - November 5, 2003: Roll-out in London.
  - November 14, 2003: Presentation in Houston (At Rice University!!)
- Getting hard numbers was a daunting task.
  - Oil and gas depletion is a “black hole” guess.
  - Data for the cost of replacement energy assets is hard to find.
- The numbers are mind boggling.



# A Sample Of Current Energy Costs

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- Top 10 public E&P companies spent \$195 billion (2000 - 2002) to grow production from 22.4 to 24.1 million BOE/day.
  - Acquisitions encompassed \$58 billion, which created 93% of growth.
- Decline rates of existing oil and gas supply will consume all of current base within 10 - 15 years.
- So few new energy assets have been added that little data for real costs exists.
  - Deepwater rig experience.
  - India's new refineries.

# Who Will Pay The Energy Bill?



- If we can expand energy, it will be extremely costly.
- There are only two groups to foot this bill.
  - Energy consumers.
  - Governments (who tax consumers).
- Finding the funds is easy if returns are visible, safe and attractive.
- Free markets do not throw money at bad investments (knowingly).

# The World Needs A Fast Energy Wake-Up Call

- Energy complacency is still common.
- Too many energy experts assume costs will fall.
- Energy cost must rise (to pay the cost of future energy).
- Rising energy prices, alone, do not assure success.
- Oil and gas are peaking in many regions.
- One regions peak, price becomes a “one-way street.”



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# Energy Infrastructure Spending Holds All The Keys

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- Without recreating energy cushions, global economies cannot grow.
- The existing energy base must be rebuilt.
- Only time and cost are unknown factors.
- Future could be grim if this job is not done.

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